

## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification<sup>5</sup>:

A61B 5/117

A2

(11) International Publication Number:

WO 94/22371

(43) International Publication Date:

13 October 1994 (13.10.94)

(21) International Application Number: PCT/US94/01921

(22) International Filing Date: 24 February 1994 (24.02.94)

(30) Priority Data:

08/040,878

31 March 1993 (31.03.93)

US

(71) Applicant: DIGITAL BIOMETRICS, INC. [US/US]; Suite 205, 5600 Rowland Road, Minnetonka, MN 55343 (US).

(72) Inventors: FISHBINE, Glenn, M.; 11925 Runnel Circle, Eden Prairie, MN 55347 (US). WITHOFF, Robert, J.; 18701 Stratford Road, #326, Minnetonka, MN 55343 (US). KLEIN, Theodore, D.; 2386 Chateau Lane, Mound, MN 55364 (US).

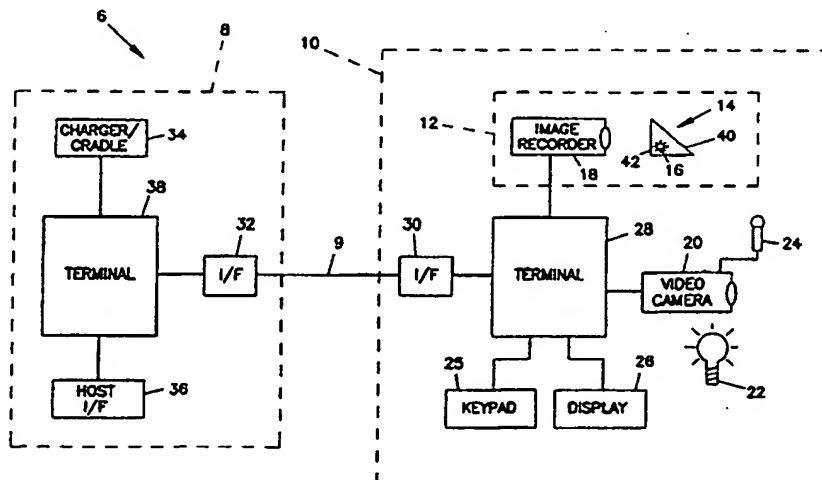
(74) Agent: BRUESS, Steven, C.; Merchant, Gould, Smith, Edell, Welter &amp; Schmidt, 3100 Norwest Center, 90 South Seventh Street, Minneapolis, MN 55402 (US).

(81) Designated States: AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, ES, FI, GB, GE, HU, JP, KP, KR, KZ, LK, LU, LV, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SK, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published

Without international search report and to be republished upon receipt of that report.

(54) Title: PORTABLE FINGERPRINT SCANNING APPARATUS FOR IDENTIFICATION VERIFICATION



## (57) Abstract

A portable and lightweight fingerprint scanning apparatus which can optically scan and record fingerprint images in the field and transmit said images to a mobile unit for processing and subsequent wireless transmission to a central location for the purpose of providing immediate identity and background checks on the individual being fingerprinted. The apparatus of the present invention includes a fingerprint scanner for capturing a fingerprint image, a camera for capturing a photographic image of a person or a scene and means for transmitting the fingerprint image and the photographic image to a mobile unit. In the preferred embodiment the present invention includes a highly integrated camera with a superior signal to noise ratio and an infrared lighting source for illuminating a person or scene in low ambient light situations. An especially preferred embodiment of the present invention also provides the ability to preview the fingerprint and "mug shot" images on a display screen and to control transmission and processing of the fingerprint and "mug shot" images by the mobile unit using a terminal or keypad located on the portable fingerprint scanning apparatus.

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgyzstan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LU	Luxembourg	TD	Chad
CS	Czechoslovakia	LV	Latvia	TG	Togo
CZ	Czech Republic	MC	Monaco	TJ	Tajikistan
DE	Germany	MD	Republic of Moldova	TT	Trinidad and Tobago
DK	Denmark	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	US	United States of America
FI	Finland	MN	Mongolia	UZ	Uzbekistan
FR	France			VN	Viet Nam
GA	Gabon				

**PORTABLE FINGERPRINT SCANNING APPARATUS  
FOR IDENTIFICATION VERIFICATION**

5

**Background of the Invention**

**Field of the Invention**

The present invention relates to apparatus for  
10 the live scanning of fingerprint images and more  
particularly to a portable apparatus for the scanning  
and capture of fingerprint images and the wireless  
transmission of said images to a central location for  
identity verification.

15

**Description of Background Material**

Over the years, the most commonly used  
techniques for both identity verification and the  
identification of potential crime suspects have been the  
20 use of fingerprints and photographs or "mug shots".

Originally, fingerprinting was done by inking a  
suspect's finger and applying the inked finger to paper.  
As can be readily understood, fingerprint information in  
this form was difficult to use. Making a fingerprint  
25 match was an extremely time-consuming task. Digital  
technology significantly advanced the art of  
fingerprinting. Inked images could be scanned and the  
image digitized and recorded in a manner that could  
later be searched in a reasonably expeditious manner by  
30 computer. Problems arose, however, due to the quality  
of inked images. Over- and under-inking resulted in  
blurred or vague images, thus rendering the digitized  
information useless. Further, the process of scanning  
an inked image was relatively time consuming.

35

These and other problems led to "live  
scanning". According to live scanning techniques, the  
fingerprint of a suspect is scanned directly from the  
suspect's finger, as opposed to being scanned from an  
inked image of the print. More specifically, live scans  
40 are those procedures which capture fingerprint ridge

detail in a manner which allows for the immediate processing of the fingerprint image with a computer. Original work in the field dates back to original patents filed in 1964 concerning techniques used to capture high contrast images of fingerprint for photographic or digital capture of fingerprints.

Since their introduction, live scans have become an important tool for law-enforcement. The live scan has the potential to overcome inherent weaknesses in the ink capture of fingerprints and provide immediate transmission of fingerprint images; and allow for image enhancement if necessary.

These characteristics provide law-enforcement with the ability to improve the quality of the fingerprint data base, thereby improving the likelihood that identifications can be made either from latent fingerprints or from identity verification checks. In addition, live scan fingerprints are easily adaptable to computerized storage and processing techniques, increasing cooperation and fingerprint data transfer between various police agencies.

Systems which optically or optically and mechanically generate fingerprint images are in use. Several such fingerprinting systems are disclosed in Fishbine et al. (U.S. Patent Nos. 4,811,414 and 4,933,976); Ruell (German Patent No. 3423886 A1); Becker (U.S. Patent No. 3,482,498); McMahon (U.S. Patent No. 3,975,711); Schiller (U.S. Patent Nos. 4,544,267 and 4,322,163); Marcus (U.S. Patent No. 4,533,837) and White (U.S. Patent No. 3,200,704).

While the fingerprinting systems disclosed in the foregoing patents are capable of providing optical or optical and mechanical fingerprint images, said systems are only suitable or use at a central location such as the police station. It is evident that there is also a need for a portable and lightweight fingerprint scanning system which can optically generate fingerprint

images in the field. Such a portable system would be ideal for traffic officers and other law enforcement professionals who want to perform an immediate identity and background check on an individual while in the field. It is also evident that there is a need for a portable fingerprint system which has the capability for the wireless transmission of fingerprint images captured in the field to a central facility for identity verification using an automated fingerprint identification system.

It is further evident that there is a need for a portable fingerprint system which also includes the capability of capturing a photographic image or "mug shot" for wireless transmission to a central facility for identity verification using systems such as the FBI National Crime Information Center Network.

#### Summary of the Invention

The present invention is a portable and lightweight fingerprint scanning apparatus which can optically scan and record fingerprint images in the field and transmit said images to a mobile unit for processing and subsequent wireless transmission to a central location for the purpose of providing immediate identity and background checks on the individual being fingerprinted. The apparatus of the present invention includes a fingerprint scanner for capturing a fingerprint image, a camera for capturing a photographic image of a person or a scene and transmitting means for transmitting the fingerprint image and the photographic image to a mobile unit. In the preferred embodiment the present invention includes a highly integrated camera with a superior signal to noise ratio and an infrared lighting source for illuminating a person or scene in low ambient light situations. An especially preferred embodiment of the present invention also provides the ability to preview the fingerprint and "mug shot" images

on a display screen and to control transmission and processing of the fingerprint and "mug shot" images by the mobile unit using a terminal or keypad located on the portable fingerprint scanning apparatus. The  
5 present invention allows law enforcement professionals to perform immediate identity and background checks on an individual while in the field.

#### Brief Description of the Drawings

10 FIG. 1 is a block diagram representation of an apparatus which can be used to capture fingerprint and photographic images in the field and transmit said images to a central location for identification verification in accordance with the present invention.

15 FIG. 2 is a perspective view of the finger prism shown in FIG. 1.

FIG. 3 is a side view of the finger prism shown in FIG. 2.

20 FIG. 4 is a top view of the finger prism shown in FIG. 2.

FIG. 5 is a representation of one embodiment of a package used to house the portable image collection unit of FIG. 1.

25 FIG. 6 is an electrical block diagram representation of an integrated fingerprint scanning camera which can be used advantageously in the system shown in FIG. 1.

30 FIG. 7 is an electrical block diagram representation of an integrated pair of cameras which can be used advantageously to capture both fingerprint and mug shot images in the system shown in FIG. 1.

#### Detailed Description of the Preferred Embodiments

35 In the following Detailed Description of the Preferred Embodiments, reference is made to the accompanying Drawings which form a part hereof, and in which is shown by way of illustration specific

embodiments in which the invention may be practiced. It is to be understood that the other embodiments may be utilized and structural changes may be made without departing from the scope of the present invention.

5           A portable identification verification system 6 which can be used to optically capture and produce fingerprint and other photographic images in accordance with the present invention is illustrated generally in FIG. 1. System 6 includes a base unit 8 connected over  
10 a data transmission interface 9 to a portable image collection unit 10.

          Base unit 8 includes an interface circuit 32, a charger/cradle 34 and a host interface 36 all interfaced to terminal 38. Portable image collection unit 10  
15 includes fingerprint scanner 12, camera 20, keypad 25, display 26 or interface circuit 30 all interfaced to terminal 28. In one preferred embodiment, terminals 28 and 38 are based on the Motorola 68340 microprocessor in order to reduce the number of peripheral circuits  
20 required. In addition, in one preferred embodiment, terminals 28 and 38 include one or more SCSI interfaces, one or more frame grabbers, a high speed serial link and a system interface.

          Fingerprint scanner 12 consists of a finger  
25 prism 14 and a scanning camera 18. Fingerprint images from the portion of a finger placed in contact with receiving surface 40 of finger prism 14 are imaged by scanning camera 18. Scanning camera 18 includes a lens and imaging medium (not separately shown). Fingerprint  
30 images generated by fingerprint scanner 12 can be displayed on display 26 and transmitted by interface circuit 30 to base unit 8 for further processing. In the preferred embodiment, base unit 8 is mounted in a mobile unit such as a patrol car. Camera 20 generates a  
35 photographic image, or "mug shot", of the person being fingerprinted. Camera 20 can also be used to capture a picture of the scene being investigated. The image

generated by camera 20 can be displayed on display 26 or transmitted by interface circuit 30 to base unit 8 for viewing or recording.

Keypad 25 can be used by an operator to  
5 interface with portable identification verification system 6. Through keypad 25, an operator can control the various functions supported by transmitter 28. For instance, keypad 25 can be used to display an image from fingerprint scanner 12 or camera 20 on display 26.  
10 Keypad 25 can also be used to transmit control signals to base unit 8 over data transmission interface 9 or to transmit images from terminal 28 to terminal 38 over interface 9. In one embodiment, keypad 25 is a four button, back-lit keypad having the following functions:

- 15       MODE:       Toggles between fingerprint and mug shot mode (the system powers up in mug shot mode).
- 20       CAPTURE:   Causes image collection unit 10 to freeze the current image (fingerprint or mug shot) and send it to base unit 8 for processing.
- 25       MENU:       Causes the system to enter "menu" mode, blanks display 26 and lists a number of functions with the topmost function high-lighted. Subsequent depressions of the  
30       MENU button scrolls the list to high-light alternate functions.
- SELECT:      Causes the high-lighted function in the display menu to be performed.

35       In an alternate embodiment, a twelve key pad similar in layout to the dual-tone multifrequency (DTMF) keys of a touch tone telephone can be used in addition to the four button keypad to provide greater flexibility in data entry. Even further flexibility in input/output  
40 can be gained by substituting a pen-based interface for keypad 25 or by installing a small scale QWERTY keyboard (as in a notebook computer). Other input/output devices can be used to supplement or replace keyboard 25. For instance, keypad 25 could be replaced with a magnetic



card reader or a bar code scanner. In addition, a breathalyzer circuit might prove particularly advantageous for processing people suspected of driving while intoxicated. In the preferred embodiment, each  
5 such input/output device is treated as a peripheral device by a processor in terminal 28.

In the preferred embodiment, portable image collection unit 10 sits in charger/cradle 34 when not in use. When unit 10 is removed from charger/cradle 34, it  
10 powers up and can be used to acquire images. In that embodiment, unit 10 is encased in a single housing and is designed to be small enough and light enough for use in the field by such people as law enforcement personnel.

15 In one preferred embodiment, image collection unit 10 may be implemented as a two-part system; the top half holds the optics, computer systems and operator controls and the bottom half is designed as a removable center channel having various options for  
20 interconnection to base unit 8 (tether, RF link, disk drive, etc.). Both halves of unit 10 connect together via, for instance, a PCMCIA interface for standardization.

In one embodiment, the two-part system is  
25 implemented as a two-part injection-molded case with the top half of the case having a writing surface and keypad 25 and the bottom half being essentially a shell. One example of such a housing is shown, for example, in FIG. 5. In the unit 10 of FIG. 5, housing 52 has two side  
30 surfaces 53, a top surface 54, a bottom surface 55, a front end surface 56 and a back end surface 57.

Top surface 54 includes a writing surface 58 and a user interface surface 59. User interface surface 59 contains display 26 and keypad 25. Keypad 25 has  
35 four buttons 25.1-4 corresponding to the MODE, CAPTURE, MENU and SELECT buttons, respectively, described above. In one preferred embodiment, writing surface 58 includes

a clip (not shown) for clipping a tablet of citations to writing surface 58.

Front end surface 56 includes illumination source 22, a filter 21 for camera 20 and finger  
5 receiving surface 40 of fingerprint scanner 12. In an alternate embodiment, camera 20 and illumination source 22 may be placed adjacent to each other so as to share filter 21.

In the preferred embodiment, housing 52 can be  
10 screwed together to allow for repair if needed. The interface circuit 30 option selected should screw into the center channel (not shown) of the bottom case. In the preferred embodiment, the screws should extend all the way into the top half of the case for mechanical  
15 strength. In a further preferred embodiment, a PCMCIA or SCSI connector is provided on the back end surface 57 in order to permit connection to an external device.

In operation, image collection unit 10 is carried, for example, by a police officer to the scene  
20 of an investigation. Persons to be identified are photographed and fingerprinted, the scene is photographed and unit 10 transfers the resulting images to base unit 8 in the patrol car. From there the mug shot, scene and fingerprint information can be  
25 compressed and sent to the police station for comparison against existing mug shot and fingerprint images or for review by other investigators. By expediting the process of obtaining and verifying fingerprint and mug shot images, system 6 provides a better and faster  
30 method of verifying an individual's identity. This expedited identification not only fosters efficiency in the investigation but also provides knowledge critical to protecting an officer's safety.

Optical devices such as finger prism 14 are  
35 well known and disclosed, for example, in McMahon U.S. Patent No. 3,975,711; White U.S. Patent No. 3,200,701; and Fishbine et al., U.S. Patent Nos. 4,792,226,

4,811,414 and 4,933,976. These devices use the optical principle of total internal reflection. When a finger is positioned on finger receiving surface 40 (a planar surface in the preferred embodiment but a curved surface could be used), an optical image of the ridge and valley pattern on the surface of the finger (i.e., the fingerprint) is propagated from image propagation surface 42. Finger prism 14 is best described with reference to FIGS. 2 - 4. Finger prism 14 is an optical device fabricated of a light propagating material, such as plastic, glass or a combination thereof, which is characterized by an index of refraction. As shown, finger prism 14 has a sloping upper surface or finger receiving surface 40 and a rear or image propagating surface 42. Finger prism 14 also includes a bottom surface 44 and two side surfaces 46. Illumination is provided on side surfaces 46 by illumination source 16. In the preferred embodiment, illumination source 16 consists of light-emitting diodes attached to side surfaces 46 of finger prism 14. Bottom surface 44 is coated with an opaque material such as black paint. Finger prism 14 has overall dimensions such that finger receiving surface 40 can receive and image at least one finger 50. Image propagating surface 42 is perpendicular to bottom surface 44. In one preferred embodiment in which finger prism 14 is manufactured of acrylic material, A1 is 45° and A2 is 20°. Finger prism 14 is designed to utilize the optical principle of frustration of total internal reflection. These optical principles are described in Fishbine et al. U.S. Patent No. 4,811,414 which is hereby incorporated by reference. These properties result in a visual fingerprint image of a finger placed on image receiving surface 40 being propagated through image propagation surface 42. The fingerprint image has "light" areas corresponding to ridges of the fingerprint and "dark" areas corresponding to valleys of the fingerprint. Other means or optical

devices which provide fingerprint images can also be used.

Scanning camera 18 is mounted with respect to finger prism 14 and configured in such a manner that its field of view encompasses the entire image propagation surface 42. Scanning camera 18 continuously images fingerprint images through its objective lens onto its image recording media resulting in an image representative of the light reflected from the parts of the finger 50 in contact with the image receiving surface 40. The recorded image looks like the photographic negative of the fingerprint image. In one embodiment, scanning camera 18 is a video camera that continually images fingerprint images through its objective lens, and generates frames of video signals representative thereof. Any commercially available video camera, such as a Model XC-77 video camera manufactured by Sony Corporation, can be used. In such an embodiment, a frame grabber (not shown) in terminal 28 receives the standard video signal from the video camera, converts the video signal to a series of digitized frames and stores the digitized frames to terminal 28 memory for display and/or transmission to base unit 8.

The embodiment of scanning camera 18 described above has some shortcomings. Typically, available video cameras are constrained to video signal outputs which fit into one of the popular television signal formats. For instance, a typical video camera produces a NTSC video signal. Therefore, video resolution is limited to the resolution available to an NTSC video camera. This level of video resolution has been adequate but, due to the requirement of fitting the NTSC format, there were no apparent options for increasing video resolution. In addition, the approach of using a commercial video camera introduces two sources of image degradation. First, since most commercial video cameras are based on

a CCD element, the camera must first convert each pixel in the CCD array into the NTSC scan line format. The resulting scan line is then sent over a RS170 line to the frame grabber in terminal 28. This conversion from the CCD pixel format to the NTSC scan line format and the subsequent transmission of that video signal to frame grabber results in a loss of about 20% of the information. This approach also places a limit on the pixel scanning rate due to the need to conform to the NTSC standards.

An alternate embodiment of scanning camera 18 which overcomes these limitations to produce fingerprint images having a superior signal to noise ratio is shown generally in the electrical block diagram of FIG. 6. In the system of FIG. 6, scanning camera 18 is formed by placing a lens 70 so that light from image propagating surface 42 is focussed on CCD array 72. In contrast to the video camera implementation described above, in the system of FIG. 6 an output of CCD array 72 is connected directly to terminal 28. In one embodiment, terminal 28 is formed by interconnecting a processor 74 with digitizer 76, memory 78, synchronization circuit 82 and memory mapped display card 84. Processor 74 communicates with digitizer 76, memory 78 and memory mapped display card 84 over a bus 80. Operation of processor 74, digitizer 76 and CCD array 72 is synchronized by clock signals generated by synchronization circuit 82.

In one embodiment, CCD array 72 is an array of pixel elements 73.1 through 73.p distributed as an  $m \times n$  array of pixel elements (where  $p = m \times n$ ). In one such embodiment, a 768 x 494 pixel CCD array 72 provides high resolution over a field of view encompassing image propagating surface 42. CCD array 72 is connected directly to digitizer 76 so that a discrete analog level associated with a voltage level present at each pixel 73 in CCD array 72 is transferred directly to digitizer 76.

A clock signal generated by synchronization circuit 82 clocks CCD array 72 in order to serially shift to digitizer 76 in terminal 18 the discrete analog signal associated with each of the pixel elements 73.

5 Digitizer 76, under the control of processor 74, digitizes the analog voltage sent by CCD array 72 and stores it to memory 78. Processor 74 can then access memory 78 in order to display or transmit the resulting fingerprint image.

10 In one such embodiment, CCD array 72 is clocked continuously by synchronization circuit 82 in order to produce a continuous stream of analog voltage levels to digitizer 76. Digitizer 76 digitizes the analog stream in order to determine the voltage level corresponding to  
15 each pixel element 73 in CCD array 72 and presents the resulting image to memory 78 over bus 80. Processor 74 in turn accesses memory 78 in order to obtain each image and converts the series of images into a fingerprint image. The resulting fingerprint image can then be  
20 directed to interface 30 for transmission to base unit 8 or through memory mapped display circuit 84 to display 26 for viewing by the operator.

One method of producing a fingerprint image from a series of digitized images is described in  
25 Fishbine et al., U.S. Patent No. 4,933,976, which patent is hereby incorporated by reference. Fishbine et al. discloses a method of building a composite fingerprint image from a plurality of arrays of slice data characteristic of adjacent and overlapping two-  
30 dimensional slices of the fingerprint image. That method can be used advantageously with either of the two scanning camera implementations described above.

The tight integration of CCD array 72 and digitizer 76 as shown in FIG. 6 results in a 25%  
35 increase in signal-to-noise in the digitized image. In addition, since CCD array 72 and digitizer 76 are controlled by the same synchronization circuit 82, the

resulting one-to-one match in pixels results in a 33% gain in resolution. Finally, since synchronization circuit 82 is not limited to a standard format, CCD array 72 can be scanned at its maximum rate. As a  
5 result, the system shown in FIG. 6 can achieve a much higher pixel rate than that possible when one is constrained to a standard video format.

In an alternate embodiment, where a high resolution image is not required, a slower, less  
10 expensive CCD array 72 could be used. Such an approach would also reduce cost in digitizer 76 and in the remaining digital components. Alternatively, scanning camera 18 can be formed by other types of electronic cameras or imagers (such as an electrophotographic  
15 recording device).

The digitized output of scanning camera 18 can be viewed on display 26. In the preferred embodiment, display 26 is a Hitachi LCD display having 240 x 240 pixels, eight level grey scale and an approximate 2 x  
20 2.7 inch viewing area. The digitized output of scanning camera 18 can also be transferred to base unit 8 over a tether cable having a power cord and one or more data lines or can be wirelessly transmitted by a spread spectrum embodiment of interface circuit 30. A  
25 preferred tether cable is a four conductor cable in which two conductors are shielded and the other two unshielded. The two shielded conductors form a high speed differential pair for data transfer. On  
unshielded conductor is used to supply power; the other  
30 is used to indicate the direction of data transmission.

In the preferred embodiment, the end of the tether cable that attaches to image collection unit 10 does not need a connector. It is permanently attached through the center channel of housing 52 to interface  
35 30. The other end of the cable should, however, have a connector; an Amphenol 5-pin screw-lock connector has been found to have good rough-handling characteristics.

In the preferred embodiment the center channel adapter includes a 7.2 V regulator.

When a tether is not used, battery power must be provided to image collection unit 10. In the  
5 preferred embodiment, a rechargeable battery pack is connected to unit 10 through the center channel adapter. Such a battery pack must be provided for all non-tether embodiments. It has been found to be particularly advantageous to include the battery pack as part of the  
10 adapter module for all non-tether data transfer embodiments.

When the operator desires to "capture" a fingerprint image being previewed on display 26, the operator will actuate a key on keypad 25 (such as the  
15 CAPTURE key described above). In response, terminal 28 generates a signal transmitted by interface circuit 30 to base unit 8 indicating that capture and processing of the fingerprint image should be initiated. Upon receiving the signal from terminal 28, base unit 8  
20 processes the fingerprint image in accordance with methods described in U.S. Patent Nos. 4,811,414 and 4,933,976, which are hereby incorporated by reference. After image processing and compression in base unit 8, the image can be transmitted wirelessly to a unit at a  
25 central facility, such as a police station, for identity verification using an automated fingerprint identification system such as the FBI's National Crime Information Center Network.

In an alternate embodiment, nonvolatile memory  
30 such as a fixed disk drive or a flash memory card can be attached to interface 30 in lieu of the tether or the wireless transceiver. Images captured by image collection unit 10 are stored to the nonvolatile memory for later transmission to base unit 8. In one such  
35 embodiment, power for image collection unit 10 is provided by a battery supplied as part of the



nonvolatile memory package. Such an embodiment has the advantage of almost unlimited range from base unit 8.

In one embodiment, camera 20 is a standard video camera that continuously receives images through  
5 its objective lens, and generates frames of video signals representative thereof. Commercially available video cameras using conventional rasters and scanning rates can be used. Camera 20 may, for instance, be implemented with a standard video camera such as Model  
10 XC-77 manufactured by Sony Corporation. Any commercially available video camera capable of obtaining a full face or "mug shot" image would be suitable.

In an alternate embodiment, such as that shown generally in FIG. 7, camera 20 may be implemented with a  
15 lens 60 and a CCD array 62 in a manner similar to that described for scanning camera 18 in FIG. 6. In the embodiment shown in FIG. 7, both camera 20 and scanning camera 18 are implemented with CCD arrays connected directly to frame grabber board 76. As in FIG. 6, data  
20 transferred from CCD arrays 62 and 72 to frame grabber 76 is in the form of pixel analog voltages rather than the traditional video signal. Some additional cost savings can be had by multiplexing the data line from CCD array 62 and CCD array 72 so that frame grabber  
25 board 76 processes only one image at a time.

In addition to lens 60 and CCD array 62, camera 20 of FIG. 7 would also require some sort of focusing mechanism (not shown). Well known manual focusing mechanisms could be used. In addition, an autofocusing  
30 (AF) lens could be used as lens 60 to automate the focussing of camera 20.

In one embodiment of an autofocus system for camera 20, passive sensing is used to focus an autofocus version of lens 60. In passive sensing the image itself  
35 is used (rather than an ultrasonic or infrared system) to determine if camera 20 is focussed. According to the method, horizontal scans of image data are used to

determine whether an image is in focus. Each horizontal scan line is examined and the auto-focus mechanism of lens 60 is adjusted to maximize the number of edges. In one embodiment, the serial stream of data from CCD array 5 62 to frame grabber 76 is masked to obtain the area of focus interest. The resulting image is run through two second-order differentiators (Butterworth high-pass) to obtain an edge-detect signal in the horizontal dimension, then fed to a slow-decay peak detector. The 10 voltage peak at this point is highest when the video image is sharpest; i.e., in focus. This signal is fed into a slow differentiator and comparator, which generates an error signal of the proper polarity to drive an autofocus DC motor attached to lens 60. In 15 such an approach a problem does, however, exist when the peak differentiator output falls below the comparator threshold voltage; there may need to be some initial "boot" movement to the AF system. In an alternate embodiment, this entire algorithm could be reproduced in 20 software to reduce parts count.

The two second-order differentiators are used to allow a light sensing output for use in determining auto-light sensing. The first second-order output is related to the contrast of the video image, and can be 25 peak detected similarly to the above to obtain "light needed" output.

As in the case of images produced by scanning camera 18, images generated by camera 20 may be previewed on display 26 and transferred over a tether 30 cable or by wirelessly transmission to base unit 8. When the operator viewing the image in display 26 desires to capture a "mug shot" image, the operator will actuate a key on keypad 25. In response, terminal 28 sends the digitized image via interface circuit 30 to 35 base unit 8 for storage.

In an alternate embodiment, terminal 18 may be implemented so that interface circuit 30 sends a video

signal to base unit 8. In such a system, camera 20 could be used to videotape a crime scene or to capture video of a person suspected of driving while under the influence of alcohol or drugs. The video signal  
5 transmitted by interface circuit 30 to base unit 8 could also be recorded on a video tape recorder (not shown) attached to base unit 8. In another embodiment, it may be advantageous to digitize frames of the video signal and save the resulting digitized frames to a fixed disk  
10 or other nonvolatile mass storage device.

A video logging recorder could also be used with the digital implementation of portable identification verification system 6. In one such embodiment, a video recorder connected to terminal 38 of  
15 base unit 8 is used to store digital images transferred from image collection unit 10. When unit 10 is lifted from the cradle, the logging recorder is initialized and is put into pause mode. When a captured image is received by base unit 8, the recorder could be taken out  
20 of pause for one second to record the still frame equivalent of the image. In such an embodiment, a two hour tape could be used to store up to 7200 images. In an alternate embodiment, an image stored on the logging recorder can be transferred from base unit 8 to unit 10.  
25 For instance, mug shot images stored on the logging recorder could be reviewed on display 26 by an officer interviewing a suspect or by witnesses while their memories are still fresh.

Camera 20 may also be connected to microphone  
30 24 and be provided with an illumination source 22. In one embodiment, cameras 18 and 20 are formed with CCD arrays 70 and 60 which operate down into the infrared region. In such an embodiment, illumination source 22 is formed from a plurality of infrared light emitting  
35 diodes in order to provide unobtrusive illumination capable of capturing images of subjects or scenes up to 30 feet away in total darkness.

In the preferred wireless transmission embodiment, interface circuit 30 of image collection unit 10 and the corresponding receiver in base unit 8 use spread spectrum radio frequency transmission. But  
5 any other wireless transmission means such as microwave or infrared transmission could be utilized.

Although the present invention has been described with reference to the preferred embodiments, those skilled in the art will recognize that changes may  
10 be made in the form and detail without departing from the spirit and scope of the invention.

## WHAT IS CLAIMED:

1. A system for remote identification verification, comprising:

a base unit, including means for receiving images and means for storing said images;

a portable image collection unit, wherein the image collection unit comprises:

image capturing means for capturing an image representative of a scene or a person, wherein the image capturing means comprises first image propagating means for propagating the representative image and first imaging recording means for recording the propagated representative image;

fingerprint scanning means for capturing live scan fingerprint images, wherein the fingerprint scanning means comprises second image propagation means for propagating the fingerprint image and second image recording means for recording the propagated fingerprint image; and

terminal means, connected to said image capturing means and said fingerprint scanning means, for selecting an image from a group of images including the recorded representative image and the recorded fingerprint image; and

data transfer means, connected to the base unit and the image collection unit, for transferring the selected image between the base unit and the image collection unit.

2. The apparatus of claim 1 wherein said fingerprint scanning means further comprise a contact surface adapted to receive a finger thereon.

3. The apparatus of claim 1 wherein said fingerprint scanning means further comprise a prism for receiving contact from one or more fingers and for propagating images of said fingers.

4. The apparatus of claim 3 wherein one of said first and second image recording means is an electronically shuttered CCD array.

5. The apparatus of claim 3 wherein one of said first and second image recording means is an electrophotographic recording system.

6. The apparatus of claim 3 wherein one of said first and second image recording means is a video camera.

7. The apparatus of claim 3 wherein said base unit further comprises a transmitter for wireless transmission of the selected image to a central facility.

8. The apparatus of claim 3 wherein said data transfer means include a radio frequency transmitter.

9. The apparatus of claim 3 wherein said data transfer means include a spread spectrum transmitter and receiver which can be used to transfer images between the base unit and the terminal means.

10. The apparatus of claim 3 wherein said data transfer means include a tether cable adapted to provide power to the image collection unit.

11. The apparatus of claim 3 wherein said terminal means further comprise nonvolatile memory storage for storing the selected image and wherein the data transfer means comprise means for transferring the stored image to the base unit.

12. The apparatus of claim 1 wherein said terminal means further comprise display means for displaying the selected image.

13. The apparatus of claim 1 wherein said image capturing means includes an illumination source.

14. The apparatus of claim 13 wherein said illumination source is a plurality of infrared light emitting diodes.

15. A system for remote identification verification, comprising:

- a base unit for receiving and storing images;
- a camera which can be used to capture a mug shot

image;

- an optical fingerprint scanner, the fingerprint scanner comprising means for capturing a live scan fingerprint image, wherein the capturing means comprise image propagation means for propagating the fingerprint image and image recording means for recording the propagated fingerprint image; and

- a terminal, connected to the fingerprint scanner and the camera, wherein the terminal comprises an interface circuit for transmitting to the base unit an image from a group of images including the mug shot image and the recorded fingerprint image.

16. A portable apparatus for identification verification, comprising:

- fingerprint scanning means for the capturing live scan fingerprint images, wherein the fingerprint scanning means comprise image propagation means for propagating the fingerprint image and recording means for capturing the propagated fingerprint image;

- image capturing means for obtaining an image of the person being fingerprinted;

display means for viewing an image from a group of images including the fingerprinted person's image and the captured fingerprint image;

terminal means, connected to the fingerprint scanning, image capturing and display means, for selecting the image to be viewed; and

base unit means, connected to the terminal means, for receiving the selected image.

17. The apparatus of claim 16 wherein said fingerprint scanning means further comprise a contact surface adapted to receive a finger thereon.

18. The apparatus of claim 16 wherein said fingerprint scanning means further comprise a prism for receiving contact from one or more fingers and for propagating images of said fingers.

19. The apparatus according to claim 17, wherein the terminal means comprise transmission means for transmission of the mug shot image and the recorded fingerprint images to the base unit means.

20. The apparatus according to claim 19, wherein the transmission means comprise means for wireless transmission of the mug shot image and the recorded fingerprint images.

21. The apparatus according to claim 19, wherein the transmission means comprise a tether cable having separate power and data lines.

22. Skin print apparatus, comprising:

prism means for illuminating skin placed adjacent to the prism means;

camera means for receiving light reflected from the skin via the prism means and converting the reflected



light into an output signal representative of intensity of the reflected light, wherein the camera means comprises light measuring means for measuring light received by the camera means, the light measuring means comprising a plurality of pixel elements, an analog shift register and an output, wherein each of the plurality of pixel elements comprises means for converting light incident on that pixel element into a pixel voltage representative of the light received over a period of time and wherein the analog shift register comprises means for transferring to the output an output signal comprising a representation, for each pixel element, of the pixel voltage present at that pixel element;

digitizing means, connected to the light measuring means, for converting the pixel voltage representation into an image array comprising a plurality of pixels, wherein each pixel corresponds to a pixel element;

processing means, connected to the digitizing means, for constructing a skin print image from the image array; and

synchronizing means, connected to the light measuring means and the digitizing means for synchronizing operation of the light measuring means and the digitizing means.

23. The skin print apparatus according to claim 22 wherein the light measuring means comprises a CCD array.

24. The skin print apparatus according to claim 23 wherein the processing means comprises output means for outputting the resulting skin print image.

25. The skin print apparatus according to claim 23 wherein the output means comprises a video screen.

26. The skin print apparatus according to claim 23 wherein the output means comprises a serial communications line.
27. The skin print apparatus according to claim 22 wherein the processing means comprises storage means for storing the image array.
28. The skin print apparatus according to claim 22 wherein the digitizing means comprises video formatting means for converting the pixel voltage representation into a standard video signal and video output means for sending the standard video signal to a video port.
29. A method of capturing skin print images, comprising the steps of:
- providing prism means for illuminating skin placed adjacent to the prism means;
  - providing camera means for receiving light reflected from the skin via the prism means, wherein the camera means comprises a CCD array including a plurality of pixel elements and wherein each of the plurality of pixel elements converts light received by the pixel element into a pixel voltage representative of the light received over a period of time;
  - periodically clocking the CCD array to produce a sequence of CCD output voltages representative of the pixel voltages;
  - digitizing the sequence of CCD output voltages to provide a series of digital numbers representative of the pixel voltages; and
  - processing the digital representations to produce a skin print image.
30. The method of capturing skin print images according to claim 29 wherein the method further comprises the

step of storing the digital representations before processing.

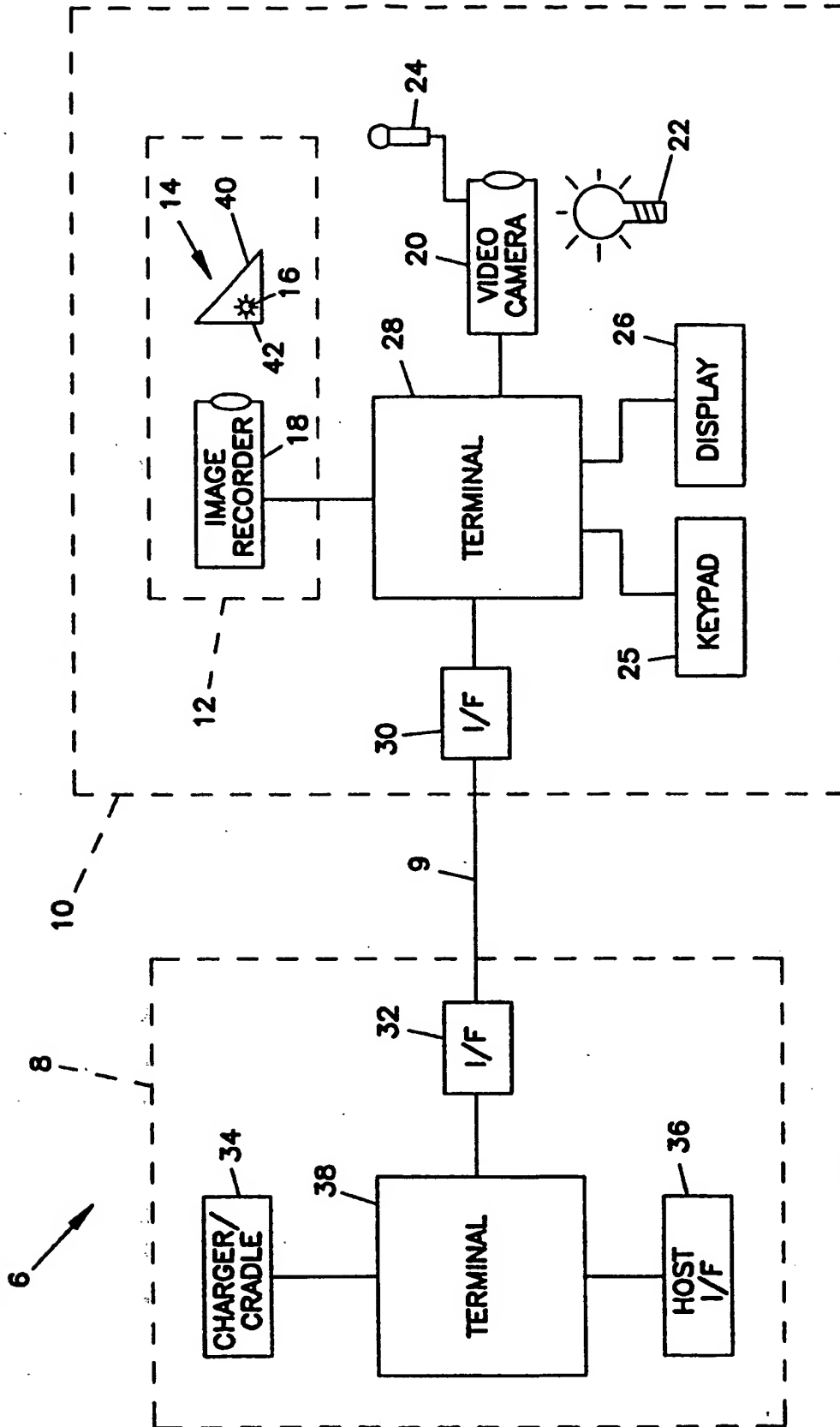
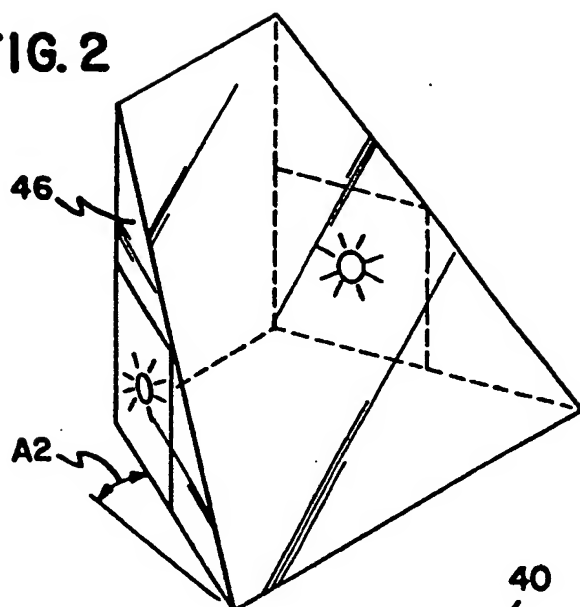
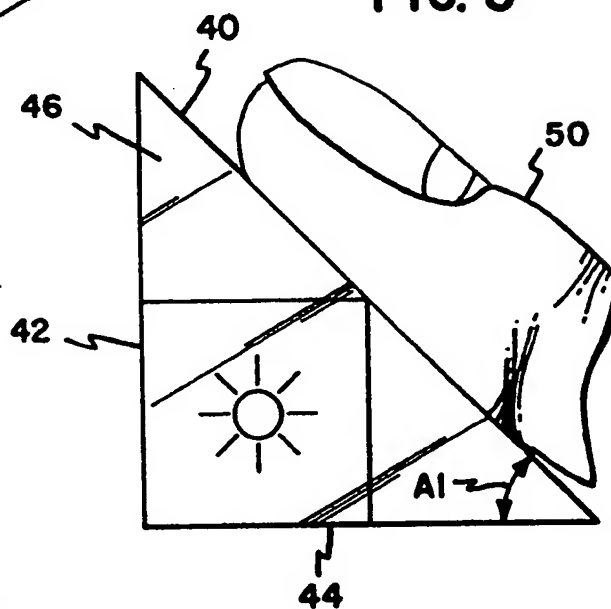


FIG. 1

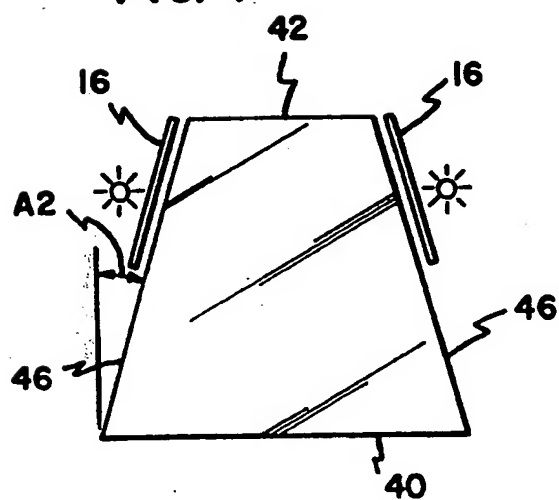
**FIG. 2**



**FIG. 3**



**FIG. 4**



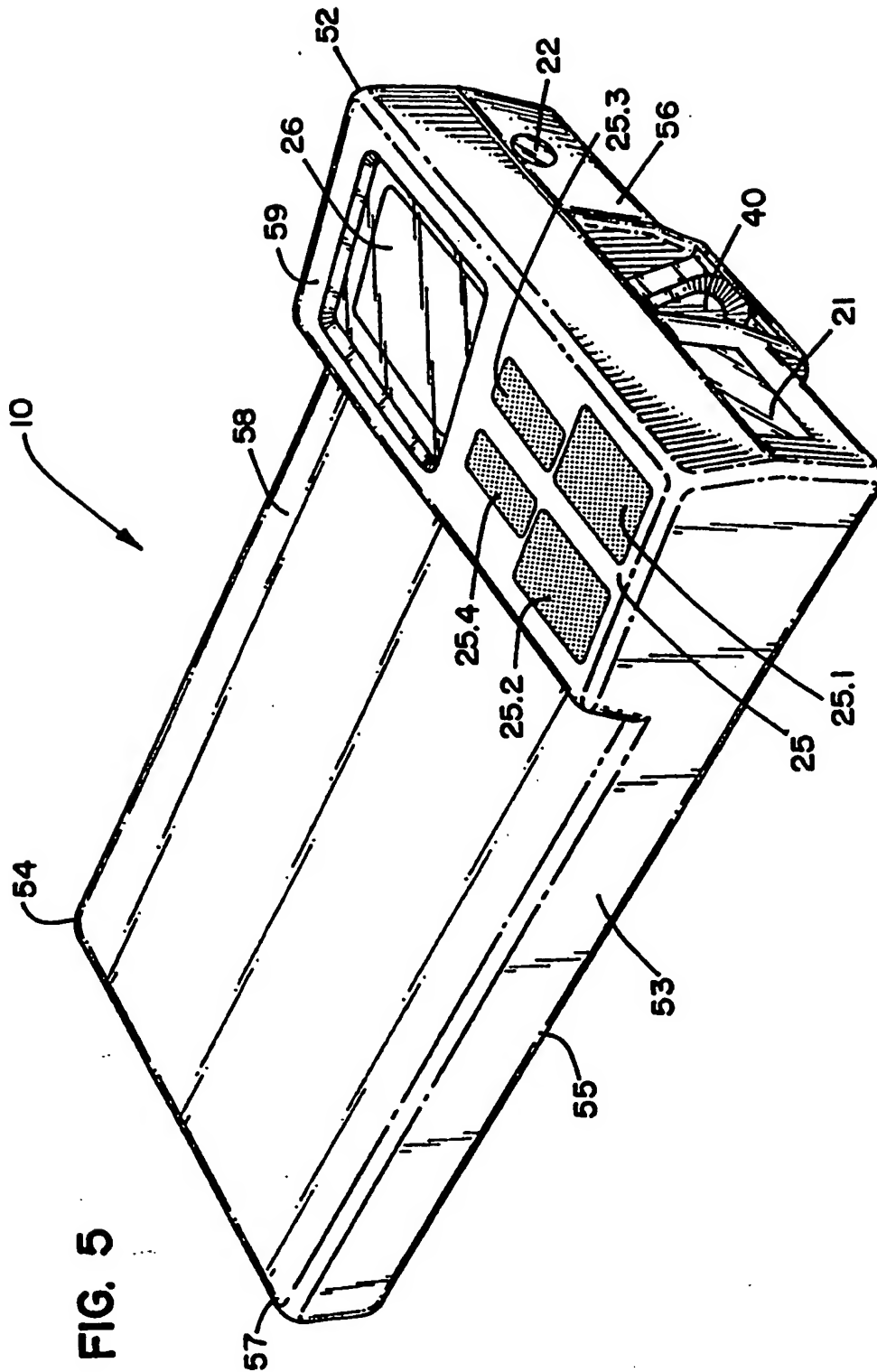


FIG. 5

BEST AVAILABLE COPY

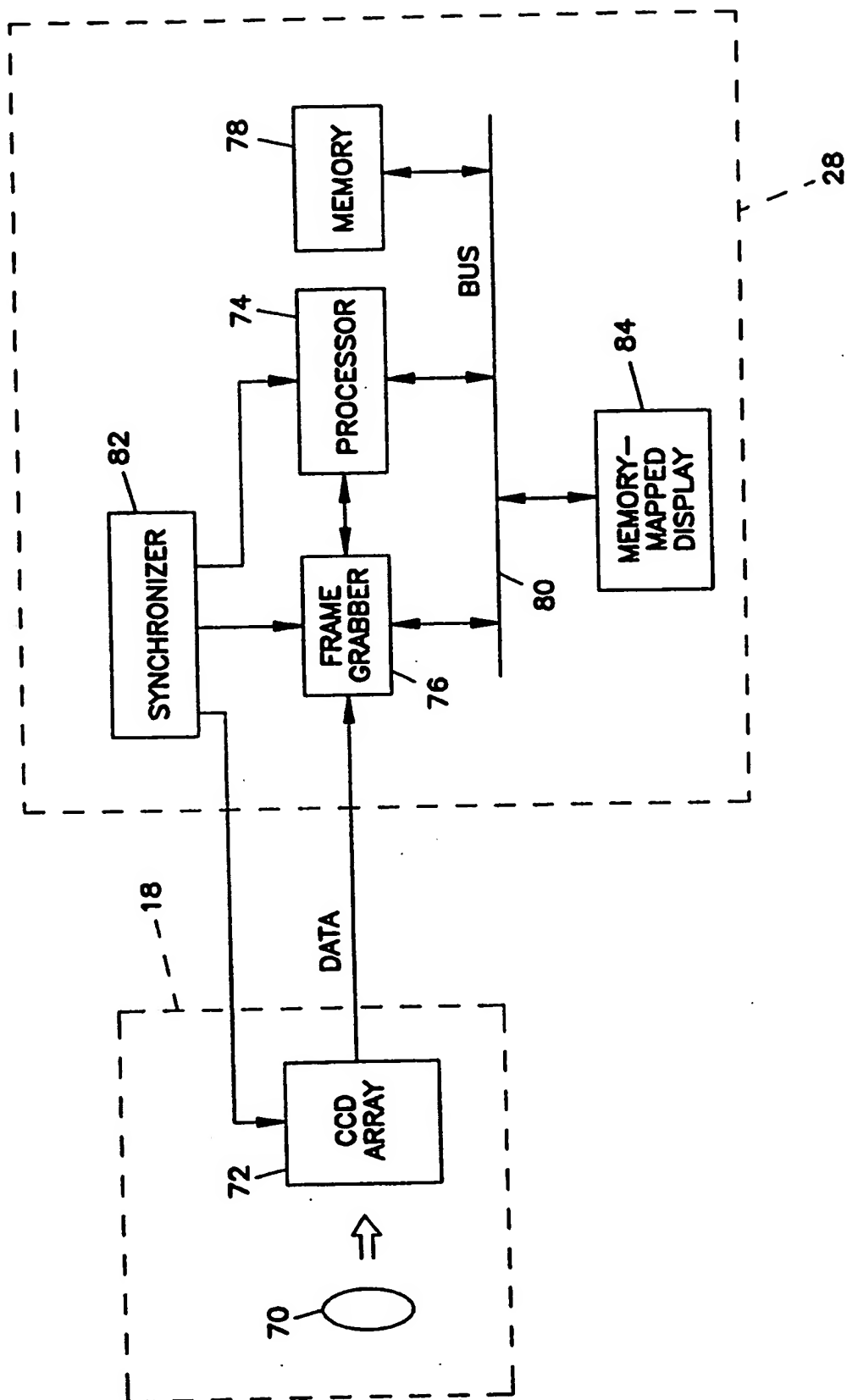


FIG. 6

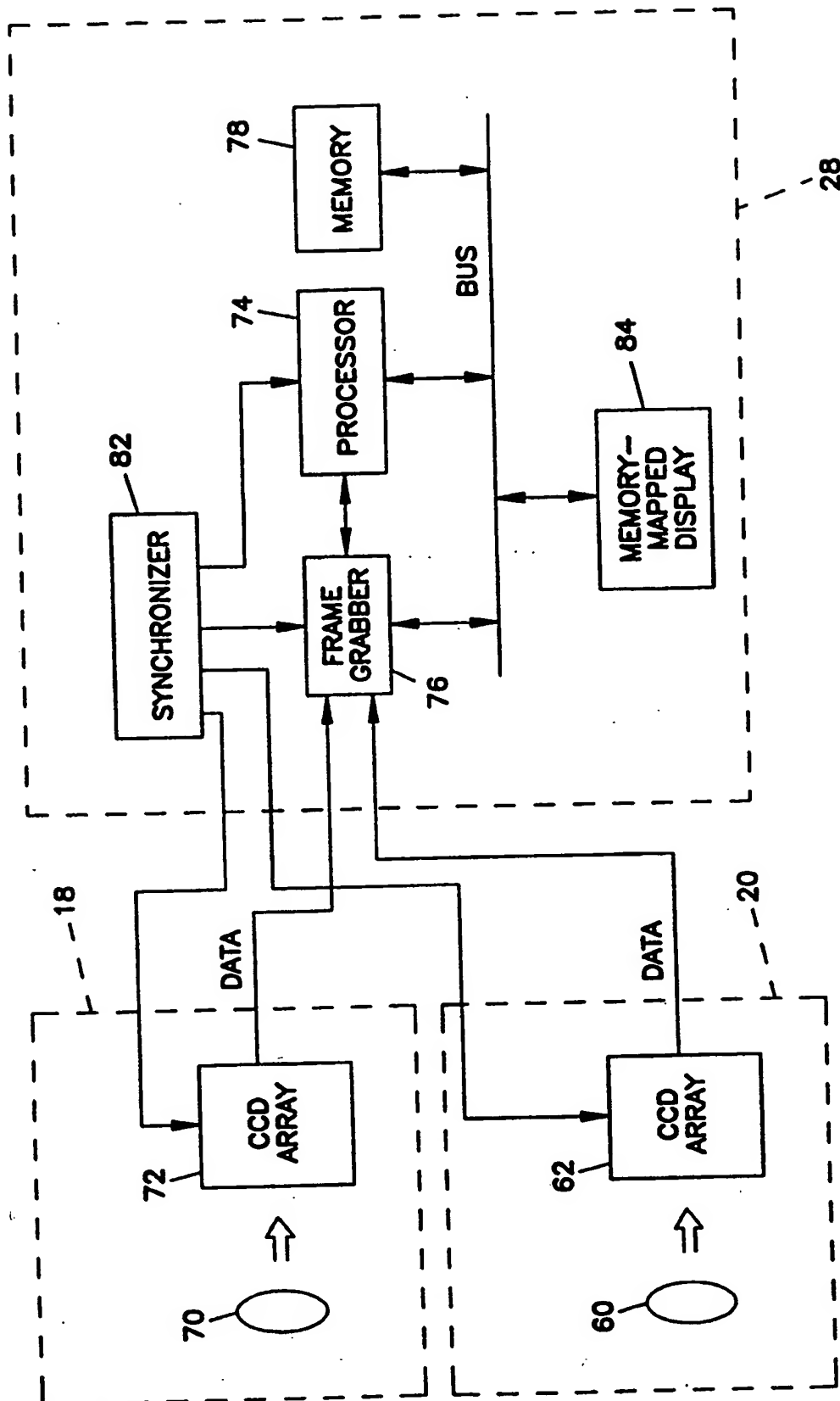


FIG. 7

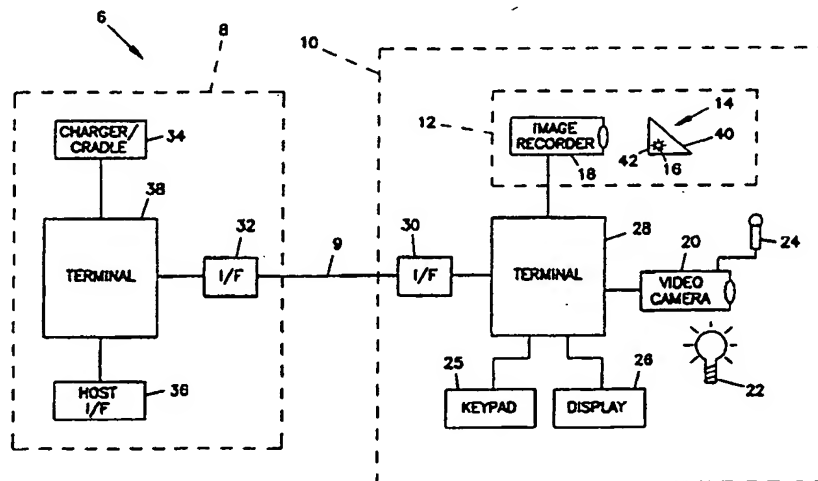




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>5</sup> : A61B 5/117, G06K 9/00	A3	(11) International Publication Number: WO 94/22371 (43) International Publication Date: 13 October 1994 (13.10.94)
(21) International Application Number: PCT/US94/01921 (22) International Filing Date: 24 February 1994 (24.02.94) (30) Priority Data: 08/040,878 31 March 1993 (31.03.93) US (71) Applicant: DIGITAL BIOMETRICS, INC. [US/US]; Suite 205, 5600 Rowland Road, Minnetonka, MN 55343 (US). (72) Inventors: FISHBINE, Glenn, M.; 11925 Runnel Circle, Eden Prairie, MN 55347 (US). WITHOFF, Robert, J.; 18701 Stratford Road, #326, Minnetonka, MN 55343 (US). KLEIN, Theodore, D.; 2386 Chateau Lane, Mound, MN 55364 (US). (74) Agent: BRUESS, Steven, C.; Merchant, Gould, Smith, Edell, Welter & Schmidt, 3100 Norwest Center, 90 South Seventh Street, Minneapolis, MN 55402 (US).	(81) Designated States: AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, ES, FI, GB, GE, HU, JP, KP, KR, KZ, LK, LU, LV, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SK, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).  Published With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.  (88) Date of publication of the international search report: 08 December 1994 (08.12.94)	

(54) Title: PORTABLE FINGERPRINT SCANNING APPARATUS FOR IDENTIFICATION VERIFICATION



## (57) Abstract

A portable and lightweight fingerprint scanning apparatus which can optically scan and record fingerprint images in the field and transmit said images to a mobile unit for processing and subsequent wireless transmission to a central location for the purpose of providing immediate identity and background checks on the individual being fingerprinted. The apparatus of the present invention includes a fingerprint scanner for capturing a fingerprint image, a camera for capturing a photographic image of a person or a scene and means for transmitting the fingerprint image and the photographic image to a mobile unit. In the preferred embodiment the present invention includes a highly integrated camera with a superior signal to noise ratio and an infrared lighting source for illuminating a person or scene in low ambient light situations. An especially preferred embodiment of the present invention also provides the ability to preview the fingerprint and "mug shot" images on a display screen and to control transmission and processing of the fingerprint and "mug shot" images by the mobile unit using a terminal or keypad located on the portable fingerprint scanning apparatus.

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgyzstan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LU	Luxembourg	TD	Chad
CS	Czechoslovakia	LV	Latvia	TG	Togo
CZ	Czech Republic	MC	Monaco	TJ	Tajikistan
DE	Germany	MD	Republic of Moldova	TT	Trinidad and Tobago
DK	Denmark	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	US	United States of America
FI	Finland	MN	Mongolia	UZ	Uzbekistan
FR	France			VN	Viet Nam
GA	Gabon				

## INTERNATIONAL SEARCH REPORT

Intern. Application No

PCT/US 94/01921

A. CLASSIFICATION OF SUBJECT MATTER  
 IPC 5 A61B5/117 G06K9/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 5 A61B G06K G07C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO,A,88 08655 (GUARDIAN TECHNOLOGIES, INC) 3 November 1988	1, 13, 15, 16
Y	see abstract	2-6, 12, 17-19
	see page 51, line 23 - line 26 ---	
Y	US,A,4 811 414 (FISHBINE ET AL.) 7 March 1989	2-6, 12, 17-19
	cited in the application see column 6, line 21 - line 58 ---	
A	EP,A,0 101 772 (J. H. LEMELSON) 7 March 1984	1, 15, 16
	see abstract see page 3, line 1 - page 4, paragraph 1 ---	
	--- -/--	



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

## \* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

\*&\* document member of the same patent family

Date of the actual completion of the international search

8 July 1994

Date of mailing of the international search report

28.10.94

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
 NL - 2280 HV Rijswijk  
 Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl,  
 Fax: (+ 31-70) 340-3016

Authorized officer

Sonius, M

## INTERNATIONAL SEARCH REPORT

Intern: Application No

PCT/US 94/01921

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P, X	WO, A, 93 10508 (DIGITAL BIOMETRICS, INC) 27 May 1993 see the whole document -----	1-21

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 94/01921

**Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

see annexed sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1, 15, 16 and their dependent claims 2-14 and 17-21

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

LACK OF UNITY OF INVENTION

## Justification

In the present application, SAE 37819, several sets of claims relating to different technical features are disclosed:

1. Independent claims 1, 15 and 16 and their dependent claims 2-14, 17-21 describe systems for acquiring and transmitting images of fingerprints and human faces.
2. Independent claims 22 and 29 and their dependent claims 23-28 and 30 describe an apparatus and method for acquiring and displaying fingerprint images.

The only feature that the above mentioned groups of claims have in common, i.e. the acquisition of fingerprint images, is well known. Hence no single inventive concept, linking the above mentioned groups of claims, can be present. Consequently the application does not comply with the requirement of unity of invention (see rule 13 PCT) -

The search has been performed, according to Art. 17,3 PCT, on those part of the international application which relate to the invention first mentioned in the claims.

## INTERNATIONAL SEARCH REPORT

Information on patent family members

Internat'l Application No

PCT/US 94/01921

Patent document cited in search report	Publication date	Patent family member(s)	Publication date	
WO-A-8808655	03-11-88	US-A-	4843377	27-06-89
		AU-B-	605583	17-01-91
		AU-A-	1594488	02-12-88
		CA-A-	1284191	14-05-91
		DE-D-	3883763	07-10-93
		DE-T-	3883763	31-03-94
		EP-A, B	0362231	11-04-90
		JP-T-	2503976	15-11-90
		US-A-	4999613	12-03-91
-----				
US-A-4811414	07-03-89	NONE		
-----				
EP-A-0101772	07-03-84	NONE		
-----				
WO-A-9310508	27-05-93	US-A-	5222152	22-06-93
		AU-A-	3179793	15-06-93
		CA-A-	2123509	27-05-93
		EP-A-	0613576	07-09-94
-----				